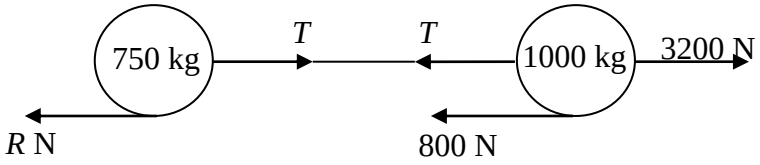
AS and A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme

Question	Scheme	Marks
1(a)	$T - 0.5g - 1.5g = 2 \times 0.5$ $T = 20.6$ (N) or 21 (N)	M1 A1 A1 **(3)**
1(b)	$R - 1.5g = 1.5 \times 0.5$ Force = 15.5 (N) or 15 (N) OR $T - R - 0.5g = 0.5 \times 0.5$ Force = 15.5 (N) or 15 (N)	M1 A1 A1 M1 A1 A1 **(3)**
		(6 marks)
2(a)	For system, $(\uparrow),\ T - 950g - 50g = 1000 \times -2$ $T = 7800\ \text{N}$	M1 A1 A1 **(3)**
2(b)	For woman, $(\uparrow),\quad R - 50g = 50 \times -2$ $R = 390\ \text{N}$	M1 A1 A1 **(3)**
		(6 marks)
3(a)	 For the whole system $R(\rightarrow)\qquad 3200 - 800 - R = 1750 \times 0.88$ Leading to $\qquad R = 860\ *$	 M1 A1 A1 **(3)**
3(b)	For the caravan $R(\rightarrow)\qquad T - 860 = 750 \times 0.88$ Leading to $\qquad T = 1520\ (\text{N})$	 M1 A1 A1 **(3)**
		(6 marks)

Question	Scheme	Marks
4	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ (OR: $15 - 0.5g - 0.75g = 1.25a$) ($a = 2.2$ m s^{-2}) $T = 6$ N	M1 A1 M1 A1 M1 A1
		(6 marks)
5(a)	$4mg - T = 4ma$ $T - 3mg = 3ma$ Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations. Reach **given answer** $a = \frac{g}{7}$ correctly *** Form an equation in T: $T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$ $T = \frac{24}{7}mg$ or equivalent, 33.6m, 34m	M1A1 M1A1 M1A1 A1 M1 A1 **(7)**
5(b)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ ms^{-1}	M1A1 **(2)**
5(c)	$3mg - T = 3ma$ $T - 2mg = 2ma$ $a = \frac{g}{5}$	M1A1 A1 A1 **(4)**
5(d)	$0 = 1.96 - 2 \times \frac{g}{5} \times s$ $s = \frac{5 \times 1.96}{2g} = 0.5$(m) Total height = $0.7 + 0.5 = 1.2$(m)	M1 A1 A1 **ft** **(3)**
		(16 marks)

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	Source paper	Question number	New spec references	Question description	New AOs
1	M1 2016	2		Dynamics of a particle moving in a straight line or plane	1.1b, 3.1b, 3.3, 3.4
2	M1 2013	2		Dynamics of a particle moving in a straight line or plane	1.1b, 3.1b
3	M1 Jan 2012	2		Dynamics of a particle moving in a straight line or plane	1.1b, 2.2a, 3.1b, 3.4
4	M1 2017	5		Dynamics of a particle moving in a straight line or plane	1.1b, 3.4
5	M1 2014	7		Dynamics of a particle moving in a straight line or plane	1.1b, 2.1, 2.2a, 3.1b, 3.4

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
1a	States that $a = -4$. $6 - 2 + a = 0$ may be seen.	**B1**	1.1b	4th Understand Newton's first law and the concept of equilibrium.
	States that $b = -5$. $-4 + 9 + b = 0$ may be seen.	**B1**	1.1b	
		(2)		
1b	States that $\mathbf{R} = 2\mathbf{i} - 9\mathbf{j}$ (N).	**M1**	1.1b	4th Calculate resultant forces using vectors.
	States that the magnitude of $\mathbf{R} = \sqrt{(2)^2 + (-9)^2}$	**M1**	1.1b	
	States $R = \sqrt{85}$ (N) or $R = 9.21\ldots$ (N). Accept awrt 9.2 (N).	**A1**	1.1b	
		(3)		
1c	States $\tan\theta = \frac{9}{2}$	**M1**	1.1b	4th Calculate resultant forces using vectors.
	Finds the value of θ: $\theta = 77.47\ldots(°)$. Accept awrt $\theta = 77.5$ (°).	**A1 ft**	1.1b	
		(2)		
				(7 marks)

Notes

1b

Award second method mark and accuracy mark for a correct answer using their *R*.

1c

Award ft marks for correct answer using their **R** vector from part **a**.

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
2a	States $F = ma$ or implies use of $F = ma$ For example, $-120 = 80 \times a$ is seen.	**M1**	3.3	4th Use Newton's second law to model motion in one direction.
	Correctly finds $a = -\frac{3}{2}$ (m s^{-2}) or $a = -1.5$ (m s^{-2}).	**A1**	1.1b	
	States $v = u + at$, or implies its use. For example, $0 = 18 + \left(-\frac{3}{2}\right)t$ is seen.	**M1**	3.1b	
	Finds $t = 12$ (s).	**A1 ft**	1.1b	
		(4)		
2b	States that $v^2 = u^2 + 2as$ or implies it use by writing $0^2 = 18^2 + 2\left(-\frac{3}{2}\right)s$	**M1**	2.2a	4th Use Newton's second law to model motion in one direction.
	Correctly finds $s = 108$ (m).	**A1 ft**	1.1b	
		(2)		
2c	States that the cyclist is not a particle, or states that the resistive force is unlikely to be constant.	**B1**	3.5	4th Use Newton's second law to model motion in one direction.
		(1)		
				(7 marks)

Notes

2a

Award ft marks for a correct answer using their value for acceleration.

2b

Award ft marks for a correct answer using their value for acceleration.

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
3a	Either states that $\tan 30 = \frac{10}{a}$ or $\tan 60 = \frac{a}{10}$	**M1**	1.1b	5th Use Newton's second law to model motion in two directions.
	Correctly find $a = 10\sqrt{3}$	**M1**	1.1b	
	Interprets *a* in the context of the question, stating $a = -10\sqrt{3}$	**A1**	3.2	
		(3)		
3b	States that the magnitude of $\mathbf{R} = \sqrt{\left(-10\sqrt{3}\right)^2 + (10)^2}$	**M1**	1.1b	5th Use Newton's second law to model motion in two directions.
	States $R = 20$ (N).	**A1 ft**	1.1b	
		(2)		
3c	States $F = ma$ or implies use of $F = ma$. For example $20 = 6 \times a$ is seen.	**M1**	3.3	5th Use Newton's second law to model motion in two directions.
	Correctly finds $a = \frac{10}{3}$ m s^{-2}.	**A1 ft**	1.1b	
		(2)		
3d	States that $s = ut + \frac{1}{2}at^2$ or implies it use by writing $640 = (0)t + \frac{1}{2} \times \frac{10}{3} \times t^2$	**M1**	3.1b	5th Use Newton's second law to model motion in two directions.
	Solves to find $t = 8\sqrt{6}$ (s). Accept awrt 19.6 (s).	**A1 ft**	1.1b	
		(2)		
				(9 marks)

Notes

3b

Award ft marks for a correct answer using their value from part **a** for the **i** component of the force.

3c

Award ft marks for a correct answer using their value from part **b** for the resultant force.

3d

Award ft marks for a correct answer using their value from part **c** for the acceleration.

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
4a	States, or implies in a subsequent step, that the resistances to motion will total $1600k$ (N). (Any variable is acceptable.)	**M1**	3.1b	4th Solve problems of connected particles in one dimension.
	Uses $F = ma$ to write $3200-1600k=1600(0.4)$	**M1**	3.3	
	Solves the equation to find $k = 1.6$	**A1**	1.1b	
	Finds the resistance forces acting on the trailer: $R_{\text{trailer}}=400\times1.6=640$ (N).	**A1**	1.1b	
		(4)		
4b	Demonstrates an understanding that the resultant force for the trailer is $T - 640$, or for the car is $3200 - 1920 - T$	**M1**	3.1b	4th Solve problems of connected particles in one dimension.
	Either states $T-640=400(0.4)$ using the trailer or states $3200-1920-T=1200(0.4)$ using the car.	**M1**	3.3	
	Correctly finds $T = 800$ (N).	**A1 ft**	1.1b	
		(3)		
4c	Uses $F = ma$ to write $-640 = 400a$	**M1**	3.3	4th Solve problems of connected particles in one dimension.
	Correctly solves to find $a = -1.6\ \text{m s}^{-2}$	**A1 ft**	1.1b	
	Uses $v^2=u^2+2as$ to write $0=25^2+2(-1.6)s$	**M1**	3.1b	
	Correctly solves to find $s = 195.31\ldots$ (m). Accept awrt 195 (m).	**A1 ft**	1.1b	
		(4)		
4d	States 'the acceleration of the car will be equal to the acceleration of the trailer' or states 'the car and the trailer will move as one'.	**B1**	3.5	4th Solve problems of connected particles in one dimension.
		(1)		
				(12 marks)

Notes

4b

Award ft marks for a correct answer using their value from part **a** for the resistance acting on the trailer.

4c

Award ft marks for a correct answer using their value from part **a** for the resistance acting on the trailer and from part **b** for tension.

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
5a	Correctly uses $s=ut+\frac{1}{2}at^2$ to write $0.9=(0)t+\frac{1}{2}\times a\times(0.8)^2$	**M1**	3.1b	5th Solve problems of connected particles using pulleys.
	Correctly finds $a=\frac{45}{16}$ (m s^{-2}) or 2.8125 (m s^{-2}). Accept awrt 2.8 (m s^{-2}).	**A1**	1.1b	
		(2)		
5b	Demonstrates an understanding that the resultant force acting on sphere B is $1.2g - T$.	**M1**	3.1b	5th Solve problems of connected particles using pulleys.
	Uses $F = ma$ to write $1.2g-T=1.2\left(\frac{45}{16}\right)$	**M1**	3.3	
	Correctly solves to find $T=\frac{1677}{200}$ (N) or 8.385 (N). Accept 8.4 (N).	**A1 ft**	1.1b	
		(3)		
5c	Demonstrates an understanding that the resultant force acting on box A is $T - F$.	**M1**	3.1b	5th Solve problems of connected particles using pulleys.
	Uses $F = ma$ to write $\frac{1677}{200}-F=0.8\left(\frac{45}{16}\right)$	**M1**	3.3	
	Correctly solves to find $F=\frac{1227}{200}$ (N) or 6.135 (N). Accept 6.1 (N).	**A1ft**	1.1b	
		(3)		

5d	Uses $v = u + at$ to write $v = 0 + \frac{45}{16} \times 0.8$	**M1**	3.1b	5th Solve problems of connected particles using pulleys.
	Solves to find $v = \frac{9}{4}$ or 2.25 m s^{-1}.	**A1 ft**	1.1b	
	Uses $F = ma$ to write $-F = 0.8a$ or $-\frac{1227}{200} = 0.8a$	**M1**	3.1b	
	Solves to find $a = -\frac{1227}{160}$ m s^{-2} or 7.66…(m s^{-2}).	**A1 ft**	1.1b	
	Uses $v^2 = u^2 + 2as$ to write $0 = \left(\frac{9}{4}\right)^2 + 2\left(-\frac{1227}{160}\right)s$	**M1**	2.2a	
	Solves to find $s = \frac{135}{409}$ (m) or 0.33… (m). Accept awrt 0.33 (m).	**A1 ft**	1.1b	
	States that the total distance travelled will be 1.23 m (0.9 + 0.33).	**B1 ft**	3.2	
		(7)		
				(15 marks)

Notes

5b

Award ft marks for a correct answer using their value from part **a** for acceleration.

5c

Award ft marks for a correct answer using their values from part **a** for acceleration and part **b** for tension.

5d

Award ft marks for a correct answer using their values from parts **a**, **b** and **c**.